CHESAPEAKE BAY LAND CHANGE MODELING TECHNICAL REVIEW

Executive summary[1]

November 25, 2008

This report provides an expert peer-review of the Chesapeake Bay Land Cover Modeling (CBLCM) program. The review evaluated four areas:

- Response to earlier STAC recommendations
- Utility of the approach for watershed modeling
- Responsiveness of the Phase V watershed model to land use/land cover scenarios
- Relevance of the modeling products to decision makers and stakeholders.

The review team was also asked to provide ideas and recommendations for next steps for the modeling program. Preliminary findings are summarized in the following sections.

Summaries provided in each section are accompanied by quotes from individual reviewers. These are intended to be illustrative, but they cannot represent the full range of well-considered comments included in the full statements provided by each reviewer. Readers are encouraged to put these quotes in context by read the full statements included at the end of the document.

Overall response to STAC recommendations

The CBLCM has clearly considered and responded to most of the major issues raised during the preliminary STAC review. Overall, the reviewers were pleased by the progress of the CBLCM effort, and feel that it is on the "right track". The CBLCM is based on a systematic approach and vetted with key stakeholders. The CBLCM is cognizant of key technical challenges and the approach is generally consistent with current standards of practice.

> *"The project has been undertaken under a fairly short time line with fairly limited resources. Given these constraints, I think the group has done very sound work. They are very honest about the limitation of the current effort. Many decisions, assumptions, and even compromises need to be made when undertaking a practical modeling effort such as this one, and the group had done a reasonable and thoughtful job along the way. We are all struggling with the same sets of open questions and choices. Feedback from this first modeling effort (on both the scientific and stakeholder sides) will likely help us all refine our methods and discover new solutions."*
>
> *Reviewer #1*

[1] Executive summary by Dr. Christopher R. Pyke, CTG Energetics, Inc. (cpyke@ctgenergetics.com). Outside experts include Gil Pontius (Clark University), Dawn Parker (George Mason University), Jack Kittle (Aqua Terra Consultants), and Brian Pijanowski (Perdue University)

AR0014981

"Overall, I am very impressed and pleased with the progress of the CBLCM. I believe that the work is well executed, thoughtful, thorough and responsive to both the STAC 2006 comments and the comments that have been made by various stakeholders."

Reviewer #4

"The current modeling approach is capable of generating a wide-range of land use/land cover scenarios for the Bay watershed. This is an impressive accomplishment and the approach is consistent with state-of-the-art practice."

Reviewer #5

The CBLCM is also clearly still a work in progress. For example, the CBLCM has developed the capability to consider alternative future scenarios; however, this capability has not yet actually developed the range of scenarios emphasized in the first STAC review (i.e., illustrative, stakeholder-based scenarios that bracket a plausible range of future conditions). The STAC review emphasized that trend (predictive) scenarios were some of the most problematic, and that is particularly useful to develop a meaningful range of alternative futures. This has not yet been done, and the CBLCM team has not yet articulated a detailed approach to their development or use (i.e., how will scenarios be developed, who will participate, who will vet them, how will they be used by the Bay Program).

Utility to watershed modeling

The CBLCM has developed and refined an approach that can deliver information on each of the land use/land cover categories required by the Phase V model within each watershed modeling segment. CBLCM currently goes further and renders land use/land cover at 30 meter resolution. The utility or reliability of information at this spatial resolution was questioned by several reviewers, and this remains an area of technical and, perhaps philosophical, challenge for the CBLCM.

The CBLCM team has articulated that high resolution land use and land cover information is important for understanding changes in urban form and in facilitating communication with stakeholders. However, information below the watershed modeling segment scale is not directly useful to the Phase V model and, in many cases, not supported by data (e.g., social or economic information about land management practices is often only available at county scales). CBLCM's current approach is enabled by SLEUTH's spatially explicit modeling approach, and the CBLCM spatially disaggregates information from other classes down to 30 meter pixels to match. However, this downscaling does not add new information – it only subdivides county-level information. Attention to these scales has the potential to confuse stakeholders and create unrealistic expectations for information at small spatial scales while providing little additional utility to the Phase V modeling effort.

The reviews do not support any specific consensus conclusion or recommendation on this issue, and opinions on the technical issues involved were divided among the reviewer. For example,

"Although the SLEUTH model estimates are scaled up to create land-use proportions, it was clear from our discussion that there is high utility to having a finer-scale, spatially explicit model, and it allows stakeholders to understand and relate to the modeling effort, and to help identify where the model is not doing well and why. Given that the

projections are reasonable when scaled up, the stakeholder acceptance is sufficient reason to maintain the finer scale LUCC modeling effort."

Reviewer #1

"I still do not see a tremendous value-added by predicting the pixel scale land changes. If this fine resolution is necessary to gain credibility with the public, then one must wonder how long this credibility will last, when a resident expresses concern about a specific property and then the scientists tells her that the model is not meant to be accurate at the property scale."

Reviewer #3

Responsiveness of Phase V to land use/land cover scenarios

The Bay Program did not provide sufficient information to address this question. The reviewers were to identify hypothetical issues in coupling the CBLCM products with the Phase V model. However, the Program has not yet provided analytical results from actual coupled simulations that would allow for the evaluation of the actual relationship between the two systems.

For example,

"I can't evaluate this point, since to my knowledge the LUCC model has not been coupled with the water quality model."

Reviewer #1

I am not familiar with the details of the Phase V model setup. The underlying HSPF model has sufficient flexibility to model forecast land use/land cover change impacts. A comparison of loadings from areas with significant land use/land cover changes to loadings from more static areas will indicate the plausibility of the results.

"The prevalence and efficacy of various management practices within each model segment are a potential source of significant uncertainty in the watershed model results. The uncertainty of watershed loadings due to BMP issues should be bounded."

Reviewer #2

"We did not discuss the Phase V watershed model very much on the phone. I have searched the documents that I received and have not found any description of the Phase V watershed model."

Reviewer #3

The HSPF watershed model underlying the Phase V model should be responsive to the types of changes simulated by CBLCM. However, absent a systematic sensitive analysis, the reviewers cannot yet provide feedback on the nature of the relationship. It would useful to have a systematic understanding of the relative important of each of the input land use/land cover categories in determining water quality conditions (i.e., the combination of the quantity of uses and their relative impact on conditions).

AR0014983

Relevance to decision making

The CBLCM is driven by the goal of providing land use/land cover inputs to the Phase V modeling exercise. The implication is that the Bay Program has a clear idea about the specific decisions that Phase V supports and, indirectly, the decisions CBLCM supports. However, the information following through this chain was not clearly conveyed to the review team, and individual reviewers had strong opinions about the past, present, and future relevance of model results to policy and management:

> *"The first thing that stands out in my experience of the telephone conversation is that there is a legitimate concern that this research will not impact policy as much as we desire due to a variety of factors. A reason for this concern is that a similar previous study was not effective in mobilizing policy makers. Claggett suspects that one of the reasons for the lack of past effectiveness was that the resolution of the mapping was too coarse. I suspect that there may be several reasons. I do not have the details of the previous project, however I know that many projects fail to make the desired policy impact because they take the approach that the scientist will establish credibility by doing a technically sophisticated analysis, which will then be downloaded onto the policy makers who are supposed to use the science in an intelligent manner. This rarely works. The present project is taking many steps to avoid this unproductive path and this review encourages the project to continue additional such steps."*
>
> Reviewer #3

The CBLCM appears best suited to informing decision making Bay-wide or tributary-level decisions. At these scales, land use scenarios are likely to be robust to a range of process-related uncertainties. In other words, local errors and uncertainties should, on average, cancel themselves out and provide a relatively central tendency for each Phase V input for each segment. This should allow the CBLCM to provide important information to inform water quality management and ecosystem restoration decisions.

> *"The maps generated through the modeling approach are appropriate for addressing Bay-wide management issues where they are likely to be robust to a range of assumptions."*
>
> Reviewer #5

The CBLCM approach is less likely to be adequate at county and municipal levels. The limitations of the current modeling approach may create unacceptable inconsistencies between modeling results and local expectations. For example,

> *"Since the SLEUTH component is calibrated using historical trends in impervious surface, I believe that it assumes fixed relationships between impervious surface and urban area. This means that the model cannot be used, I believe, to examine how a decrease in imperviousness in urban area could mitigate water quality problems."*
>
> Reviewer #1

Moreover, at these scales the CBLCM approach must be compared to alternatives such as Maryland's Reality Check. The Bay Program must clearly articulate the role of the CBLCM and describes the relevance of the scenarios to specific decisions.

Some of the uncertainty regarding policy impacts appears to stem from the need for further clarification about goals and specification of more tangible performance objectives.

> *"I recommend that the project begin by stating specifically what the goals are and to specify measureable tasks to attain those goals. For example, a stated goal has been to generate scenarios that are "as accurate and as credible as possible". I realize that this was a previous goal and that there are plans to revise this goal, which is a good thing. The project should feel comfortable in revising its goals as it learns more information. I think such a goal would lead to problems because it focuses more on the technical aspects of modeling than on the policy aspects of actions."*
>
> Reviewer #3

Reviewer #3 goes on to elaborate on a range of alternative programmatic goals and performance measures, including frequency or quality of public communications and impact and implications for monitoring systems for important variables. Reviewer #3 explains the rationale for this recommendation as,

> *First, I suspect that the system has so much uncertainty that the production of accurate scenarios is potentially hopeless, and the creation of plausible scenarios might include a range that is so large that the scenarios might not be particularly helpful. It might be best to use what we have learned from the modeling so for in order to estimate what the most important factors will be, and then to set up a monitoring system to see if those factors sound any alarms in the future. For example, Pijanowski stated that changes in agriculture could cause unprecedented change is nutrient loading from agriculture. This could be important but would never be highlighted in a model that uses past trends to extrapolate into the future.*
>
> Reviewer #3

A related issue influencing the relevance of modeling results to policy is the so-called "signal-to-noise" ratio. In other words, will differences between land use and land cover scenarios make an appreciable difference with respect to Bay management objectives (e.g., resource protection, water quality restoration)?

> *"Land change is usually only a few percent of the landscape, even at rates that are considered high. So differences among plausible scenarios will be even smaller than a few percent, which is likely to cause less variability in the output than other types of uncertainties."*
>
> Reviewer #3

Summary

Overall, the reviewers agreed that in many ways the CBLCM approach is:

- Moving in the "right" direction.
- Consistent with current standards-of-practice.

- Generally representative of the state-of-the-art for the modeling community associated with the work.
- Informed by interaction with stakeholders, particularly state partners
- Capable of generating land use/land cover scenarios to inform Bay-wide and tributary-scale management issues.

The reviewers pointed out a number of important limitations associated including:

- Lack of clear, measurable objectives (i.e., beyond the qualitative objective of making scenarios as "accurate and credible as possible")
- Use of methods that provide limited control or representation over policy-relevant processes (e.g., transportation and accessibility)
- Challenge of understanding the reliability and characteristics of model outputs with relatively high levels of spatial detail across a relatively large number of land use and land cover categories.
- Limited assessment or communication about the relevance of model findings to specific management decisions
- Lack of information about the sensitivity of the Phase V model to the outputs from the CBLCM scenarios

The CBLCM has evolved into a highly complex and technical activity. However, despite this complexity, it does not have explicit consideration for many of the fundamental drivers of land use/land cover change in the region: transportation, land use policies, agricultural economics, and energy policy. The lack of consideration for these issues is an intrinsic feature of a SLEUTH-based modeling framework (i.e., simplified, pattern-based conceptualization of land use/land cover change). This strategic offers practical advantages, but it also has intrinsic limitations and may leave decision makers without clear opportunities to evaluate the consequences of programmatic or policy responses to the patterns generated by the CBLCM. This issue may become acute when the Bay Program attempts to generate alternative land use/land cover scenarios.

> *"The model excludes some important other drivers of land-use change, both spatial (new transportation infrastructure and travel costs) and behavioral (interest rates and credit availability). There is also currently no means to model drivers of changes in land management (for example, what residents might implement best management practices and why)."*
>
> *Reviewer #1*

Additionally, other approaches have emerged since the inception of the CBLCM approach, and some of these should be carefully evaluated. For example, metropolitan regions across California have adopted the iPLACE3S modeling approach (e.g., the Central Valley of California). iPLACE3S emphases the role of transportation and land use planning in regional growth and development. Alternatively, Reviewer #4 suggests the modeling team review a recent report titled, "The Use of Models in Great Lakes Decision Making: An Interdisciplinary Synthesis." Reviewer #4 also conveys recent experience where "simple planning metrics" provide important communication devices for stakeholders and the use of, *"...visioning/expert judgment techniques to elicit input from stakeholders about what the future*

might look like. We use this information to help either configure new scenarios or, in some cases, generate a reference map to compare our projects against experts..."

Overall, the CBLCM has evolved to the point where it can deliver products that "look right": maps of so-called "trend" land use/land cover futures. The team has communicated with stakeholders and developed a reasonable plan for future work. However, dramatic changes in the economics of land use and energy (e.g., downturn in the housing market, increasing fuel prices, growing concern over greenhouse gas emissions, expansion of biofuel production) undermine historically based "trend" scenarios. Moreover, the first STAC review provided substantial feedback on the limitations of "trend" scenarios and the importance of a carefully developed set of policy-relevant scenarios. These recommendations have not yet been fully considered.

Reviewer #1 concludes, *"The next step is to make the most of the opportunity for scenario analysis and stakeholder feedback... I also encourage you* [CBLCM] *to produce families of estimates, using alternative methods, and examine the extent to which they tell a common story."*

Reviewer #3 concludes, *"A major limitation is that I do not see that the scenarios and modeling are related to any specific proposed policy initiative. It would be helpful if the scenarios were based on proposed legislation. This would certainly put the modeling results in the newspaper and get people involved."*

Reviewer #4 concludes, *"One of my major points in 2006 was that emphasizing scenarios over prediction is more of a modeling communication paradigm. Using the term "prediction" emphasizes that you are trying your best to consider all factors of change to generate a "prediction" map in the future. Accuracy is the main aim of prediction. Scenarios, however, emphasize "plausible" futures. If modelers and stakeholders can agree that a future map is plausible, then the discussion focuses on the implications of that future map to valued outcomes."*

The program must also do more to understand and communicate the relationships between land use/land cover outputs and the response of the Phase V watershed model. Finally, the CBLCM team should clearly articulate the opportunities and constraints for the use of its products with respect to specific policy making and resource management decisions. A lack of explicit guidance increases the risk that products will be misused and misinterpreted.

CHESAPEAKE BAY LAND CHANGE MODELING
TECHNICAL REVIEW AND COMMENT

STAC lead: Chris Pyke (CTG Energetics, Inc.)

STAC: Ted Graham (WCOG), Claire Welty (UMBC), Denise Wardrop (PSU), Gerrit Knaap (UMD College Park), Carl Hershner (VIMS), Don Weller (SI), Lisa Waigner (Chesapeake Biological Laboratory), Doug Lipton (UMD College Park)

Outside Experts: Gil Pontius (Clark University), Dawn Parker (George Mason University), Jack Kittle (Aqua Terra Consultants), Brian Pijanowski (Perdue University)

Introduction

The Chesapeake Bay Program recognizes land use and land cover change as an important and rapidly growing threat to regional water quality and living resource restoration activities. The Bay Program has initiated research to better understand the implications of future land use and land cover for program priorities. The Bay Program requested advice and comment from the Scientific and Technical Advisory Committee (STAC) on its proposed approach for modeling land use and land cover as a part of its 2030 assessment. STAC responded by organizing an internal subcommittee. The committee recognized the need for additional technical expertise, and the committee identified a small group of outside experts. STAC requested documentation from the Bay Program and asked the outside experts to consider the materials with respect to a set of charge questions. This report contains the reviewers' responses.

Goals and Scope

This review was designed to provide feedback on the Bay Program's current modeling approach and preliminary results. The goal was to better understand the proposed approach, compare it to alternatives including expert opinion regarding the "state-of-the-art", and help describe appropriate applications of the land cover modeling results for Bay Program decision makers and stakeholders. The review may also form the basis for "next steps" by the STAC and the Bay Program. The scope of the review was limited to information provided by the CBLCM program staff, including reports, Power Point presentations, and a teleconference with reviewers.

AR0014988

Change questions

STAC and outside experts will consider the following questions:

1. Evaluate the response of the Bay Program to recommendations from the pre-review panel.
    a. Which recommendations have been accepted?
    b. What recommendations have not? What are the program's justifications for not addressing specific recommendations?

2. Evaluate the approach used by the Bay Program to generate watershed modeling segment scale land use/land cover forecasts.
    a. What are the strengths and weaknesses of the approach?
    b. What are the limitations for using this information to inform management and policy making?

3. Evaluate the responsiveness of the Phase V watershed model to forecasted changes in land use/land cover.
    a. How responsive is the Phase V model to forecasted land change?
    b. Are the modeled responses plausible? If not, please explain.

4. Evaluate how the Bay Program land use/land cover products can be used with current and forthcoming land use/land cover products and potentially complementary land use/ land cover change model output (e.g., Reality Check, and SERGoM-based scenarios).
    What are the opportunities or limitations of each product for improving adaptive water quality management responses to forecasted changes in land use/cover?

AR0014989

REVIEWER COMMENTS

Reviewer #1

1. Evaluate the response of the Bay Program to recommendations from the pre-review panel.
    a. Which recommendations have been accepted?

    b. What recommendations have not? What are the program's justifications for not addressing specific recommendations?

To answer both questions at once, I find the program's response to previous suggestions, and their justification for which suggestion were followed and were ~~not, to be~~ [strikethrough by editor] very reasonable.

The group has also done an excellent job of informing us about their modeling progress since the last review, and of responding to our initial questions and requests for additional information. The project has been undertaken under a fairly short time line with fairly limited resources. Given these constraints, I think the group has done very sound work. They are very honest about the limitation of the current effort. Many decisions, assumptions, and even compromises need to be made when undertaking a practical modeling effort such as this one, and the group had done a reasonable and thoughtful job along the way. We are all struggling with the same sets of open questions and choices. Feedback from this first modeling effort (on both the scientific and stakeholder sides) will likely help us all refine our methods and discover new solutions. Modeling, like management, is an adaptive process, and there is value in moving forward, even if our first efforts have some acknowledged limitations.

On one specific point, the group has increased the extent of stakeholder participation. These efforts appear to have been very helpful in terms of model development, and they have likely increased the potential for use of the model by stakeholders in the future.

2. Evaluate the approach used by the Bay Program to generate watershed modeling segment scale land use/land cover forecasts.
    a. What are the strengths and weaknesses of the approach?

Although the SLEUTH model estimates are scaled up to create land-use proportions, it was clear from our discussion that there is high utility to having a finer-scale, spatially explicit model, and it allows stakeholders to understand and relate to the modeling effort, and to help identify where the model is not doing well and why. Given that the projections are reasonable when scaled up, the stakeholder acceptance is sufficient reason to maintain the finer scale LUCC modeling effort. What is more, over time, hopefully the water quality models will also operate at, and therefore need input at, a finer spatial scale. So, the fine-scale LUCC projections are a strength.

I am concerned about the use of SLEUTH to generate proportions of change and the use of GAME to generate quantities of change. It seems (and I could be wrong) that SLEUTH generates both proportions and quantities of change together. These quantity estimates are, I think, not used; rather, the SLEUTH proportions are used to subdivide the GAME quantities. It seems that both models (as well as the ICLUS projections) produce similar information. A decision was made to try to use parts of the

information for each model. An alternative approach might be to do multiple scenarios, using the information from each model to generate independent scenarios, then see how they compare. Basically, compare the results of several alternative modeling approaches.

The 15 land classes generated by SLEUTH need to be downscaled to create the 26 classes needed by the water quality model. This means that the model is sensitive to the validity of rules used for downscaling. In the longer run, it would be much better to have a closer match between the number of classes created by both models, or to be able to upscale the land change model classes to create inputs for the water quality model. But, in the real world, assumptions need to be made to solve these sort of practical problems that arise due to the limitations of existing models and data. I simply recommend that these limitations be clearly presented.

b. What are the limitations for using this information to inform management and policy making?

The limitations follow directly from the points presented in part 4 below: limited range of drivers, assumptions related to continuation of current trends in the future, and lack of ability to model land management modification through the land change model.

3. Evaluate the responsiveness of the Phase V watershed model to forecasted changes in land use/land cover.
    a. How responsive is the Phase V model to forecasted land change?
    b. Are the modeled responses plausible? If not, please explain.

I can't evaluate this point, since to my knowledge the LUCC model has not been coupled with the water quality model.

4. Evaluate how the Bay Program land use/land cover products can be used with current and forthcoming land use/land cover products and potentially complementary land use/ land cover change model output (e.g., Reality Check, and SERGoM-based scenarios).

I can't answer this question, since I'm not familiar with the other products listed.

What are the opportunities or limitations of each product for improving adaptive water quality management responses to forecasted changes in land use/cover?

As in any model, the opportunities and limitation for analysis and forecasting are defined by the model's structure (fixed and variable parameters, endogenous outputs, and spatial, temporal, and behavioral scales). For the purposes of coupling with the watershed model, the CBLCM produces fairly coarse spatial scale estimates of land in particular use/cover classes. So, to the extent that its projections of those classes are accurate at that spatial scale, the model should be effective for answering questions about how changes in these class proportions could affect water quality. The CBLCM also produces some estimates of the proportion of land on sewer vs. septic, also important for projecting water quality impacts. The CBLCM relies on a couple of simple drivers of land-use/cover change. The main driver is population growth. The model could therefore be used to examine the effects of increased population on water quality.

AR0014991

The CBLCM using the current composition of agricultural land to project future composition of agricultural land. In reality, agricultural production is quite dynamic, and changes in crops grown and land management are likely as incentives change in the future. (New incentives for biofuel production are one example; new regulations related to manure application are another.).

Since the SLEUTH component is calibrated using historical trends in impervious surface, I believe that it assumes fixed relationships between impervious surface and urban area. This means that the model cannot be used, I believe, to examine how a decrease in imperviousness in urban area could mitigate water quality problems.

The model excludes some important other drivers of land-use change, both spatial (new transportation infrastructure and travel costs) and behavioral (interest rates and credit availability). There is also currently no means to model drivers of changes in land management (for example, what residents might implement best management practices and why).

The authors of the model have been very upfront about these limitations of the model, and, given the time, resources, and data available for this first modeling effort, these limitations are reasonable.

5. Your overall opinion about how the Bay program effort compares to the state-of-the-art for coupling land change models to water quality models. You're encouraged to provide concise thoughts about how Peter and his colleagues can best move forward over the next year or so.

As I said above, I think they have done a good job given the time and resources available. The next step is to make the most of the opportunity for scenario analysis and stakeholder feedback. Try to maximize the extent to which you can account for potential future variation in the factors assumed fixed in the current model. I also encourage you to produce families of estimates, using alternative methods, and examine the extent to which they tell a common story.

AR0014992

Reviewer #2

Question 1: Evaluate the response of the Bay Program to recommendations from the pre-review panel.

- *Less modeling, more stakeholder participation* – The Bay Program has made significant progress in stakeholder participation. Continuing efforts are required. Additionally, the Bay Program needs to be sure that internal follow up on stakeholder feedback is communicated back to stakeholders. The modeling efforts of the Bay Program are consistent with the magnitude of the problems being analyzed.
- *Improved modeling, better scenarios* – Agricultural activities need to be incorporated in the CBLCM.
- *Complexity* – The simplification of the CBLCM from the initial 2006 approach is appropriate.
- *Scale* - The scale of the CBLCM with its aggregation to hydrologic response units is consistent with the Phase V watershed model.
- *Drivers of change* – Addition of additional drivers of urban growth should be contemplated only if the current methodology is determined to be materially deficient.
- *Uncertainty* - The Bay Program materials demonstrate an understanding of the uncertainty related to the CBLCM model results.
- *Interoperability* – Aggregation of CBLCM results to the Phase V watershed model scale has facilitated interoperability with the Phase V model. Component models in the CBLCM should read inputs and write results in industry standard open formats. This will ease the substitution of other component models and a parallel analysis using different methodologies.
- *Land use/land cover* – The Bay Program has clearly described its methodology for handling land use/land cover issues.

Question 2: Evaluate the approach used by the Bay Program to generate watershed modeling segment scale land use/land cover forecasts.

- What are the strengths and weaknesses of the approach?
- What are the limitations for using this information to inform management and policy making?

The approach used by the Bay Program in the CBLCM uses local population projections, GIS data (NLCD, land slope, impervious surfaces, public and protected lands), a growth allocation model, a sewer model and a cellular automata model to provide Phase V watershed model with land use, sewer outflows, and septic loads for various future points in time to over 2000 model segments. The focus of CBLCM seems to be on increases to urban land uses along with resulting changes to sewer and septic loads. These are important changes to consider. A quick spreadsheet analysis of the segment area projections found in file *p5_lrsegs_T3_data_v5.dbf* shows an urbanization increase of just over 25% from 2002 to 2030. The increase comes from both forest and agricultural lands. The percentage of urban land changes from 9.9% to 12.4% of the total study area. This change may not show dramatic changes in the total loads to the Bay. However, significant changes to urban fractions in areas in close proximity to the Bay will have a significant impact on adjacent sections of the Bay if not mitigated by management practices. Details from the Phase V watershed model results need to be communicated to stakeholders on both a watershed and segment basis.

Changes to agricultural practices are another component of land use/land cover forecasts that will have a significant impact on loadings to the Bay. Changes may include changes in cropping practices (pasture-

>corn) or from forest to agriculture. An analysis of the suitability of conversion of forests (about 65% of the study area) to agriculture (about 22% of the study area) and an analysis of changes to cropping practices in existing agricultural areas should be undertaken. Without strict management practices, TN loadings from areas changing from forest to agriculture will increase significantly. As with urbanization, the proximity to the Bay of converted areas will determine the magnitude of the impact of the conversion.

Question 3: Evaluate the responsiveness of the Phase V watershed model to forecasted changes in land use/land cover.

- How responsive is the Phase V model to forecasted land change?
- Are the modeled responses plausible? If not, please explain.

I am not familiar with the details of the Phase V model setup. The underlying HSPF model has sufficient flexibility to model forecast land use/land cover change impacts. A comparison of loadings from areas with significant land use/land cover changes to loadings from more static areas will indicate the plausibility of the results.

The prevalence and efficacy of various management practices within each model segment are a potential source of significant uncertainty in the watershed model results. The uncertainty of watershed loadings due to BMP issues should be bounded.

Question 4: Evaluate how the Bay Program land use/land cover products can be used with current and forthcoming land use/land cover products and potentially complementary land use/ land cover change model output (e.g., Reality Check, and SERGoM-based scenarios).

- What are the opportunities or limitations of each product for improving adaptive water quality management responses to forecasted changes in land use/cover?

The Bay Program land use/land cover products should be enhanced to account for the presence and efficacy of various management practices. The aggregation of grid based results to the 2000 model segments is appropriate given the scale of the effort.

AR0014994

Reviewer #3

These opening paragraphs provide an overview of my assessment concerning the Bay program. Subsequent pages address each of the four specific questions in sequence. Before getting into the details, let me state clearly that the overall program is performing admirably well. It recognizes that the phenomenon with which it is dealing is infinitively complex and it has a limited budget in money, time and audience's attention span. Overall, the project is making good progress, given these parameters. Strengths include the facts that: it has been holding meetings with stakeholders, it has an external review process, and it is seeking the best practices concerning integration of science and policy. The some passages of this review summarize parts of our telephone conversation for the sake of documenting its content.

The first thing that stands out in my experience of the telephone conversation is that there is a legitimate concern that this research will not impact policy as much as we desire due to a variety of factors. A reason for this concern is that a similar previous study was not effective in mobilizing policy makers. Claggett suspects that one of the reasons for the lack of past effectiveness was that the resolution of the mapping was too coarse. I suspect that there may be several reasons. I do not have the details of the previous project, however I know that many projects fail to make the desired policy impact because they take the approach that the scientist will establish credibility by doing a technically sophisticated analysis, which will then be downloaded onto the policy makers who are supposed to use the science in an intelligent manner. This rarely works. The present project is taking many steps to avoid this unproductive path and this review encourages the project to continue additional such steps.

I recommend that the project begin by stating specifically what the goals are and to specify measureable tasks to attain those goals. For example, a stated goal has been to generate scenarios that are "as accurate and as credible as possible". I realize that this was a previous goal and that there are plans to revise this goal, which is a good thing. The project should feel comfortable in revising its goals as it learns more information. I think such a goal would lead to problems because it focuses more on the technical aspects of modeling than on the policy aspects of actions.

An alternative appropriate goal could be, "How do we make the most important impact in terms of changing policy?" Measures of this goal could include: the number of times the project's maps are published in newspapers, the number times output from the project is included in letters written to legislators, the number of people who show up to the meetings that the project conducts, and the number of hours that local managers dedicate to this project.

Yet another goal could be "How do we set up a monitoring system to collect information on the most important variables?" There are several reasons why I mention this. First, I suspect that the system has so much uncertainty that the production of accurate scenarios is potentially hopeless, and the creation of plausible scenarios might include a range that is so large that the scenarios might not be particularly helpful. It might be best to use what we have learned from the modeling so for in order to estimate what the most important factors will be, and then to set up a monitoring system to see if those factors sound any alarms in the future. For example, Pijanowski stated that changes in agriculture could cause unprecedented change is nutrient loading from agriculture. This could be important but would never be highlighted in a model that uses past trends to extrapolate into the future. Also, I mention, as I did in the 2006 review, that there might be disproportional contributors to the nutrient budget, such as a few large animal farms that contribute a substantial part of the loadings. So monitoring of those sources seems particularly important. As for the dispersed effect of how people manage their lawns, you could monitor this through the actions of companies such as ChemLawn, who serve both residences and

institutions. Ultimately the loading from lawns might have more to do with how the people manage the lawns, i.e. land use, than with whether there are lawns, i.e. land cover, as I mentioned in 2006.

The second thing that stands out in my mind from the telephone conversation is that Claggett worries that after this is all done, we could find that there almost no meaningful difference among the plausible land change scenarios. Claggett is experienced and wise. I suspect the same. Land change is usually only a few percent of the landscape, even at rates that are considered high. So differences among plausible scenarios will be even smaller than a few percent, which is likely to cause less variability in the output than other types of uncertainties. One rule of thumb that I have as a scientist is that "if I am afraid that my results will turn out a certain way, then I am not really doing science". Good science should be designed so that the results will be interesting and helpful regardless of how they turn out. I hope the project considers this as they revise their goals. It might be a positive thing to conclude that change in land cover is not as important as change in land management, especially since policies to control land cover change are extremely contentious.

The third thing that stands out is that Claggett stated that the apparent sophistication of SLEUTH is one of the reasons why the project has gained credibility with stakeholders, in spite of the fact that I still have not seen rigorous tests of predictive accuracy via a validation step. I take Claggett's word that this is true; however, apparent technical sophistication maybe one of many possible ways to win the credibility of stakeholders. Credibility could be won by transparency of the process and/or by sharing of data, which the project is also doing. Ultimately, the project needs to decide whether it is more important for the stakeholders to view the modeled output as credible or for the stakeholders to be involved in the process. This relates to the overall goal of the project. The goal of creating credible scenarios is a goal that requires the scientist to legitimate his work by its level of sophistication, whereas the goal of influencing policy is a goal that requires a process of collaboration among scientists, stakeholders, and decision makers.

The next pages give my responses to the four specific questions, which are based on my reading of "STAC response to 2006review" and of the review I submitted in 2006.

AR0014996

5. *Evaluate the response of the Bay Program to recommendations from the pre-review panel.*
    a. *Which recommendations have been accepted?*
    b. *What recommendations have not? What are the program's justifications for not addressing specific recommendations?*

A high priority recommendation from the 2006 panel was more stakeholder participation. Since 2006, the project followed through with apparently tremendous benefits. Many of the stakeholders seem to be municipal employees. In the future, it might be good to diversify the definition of stakeholders to include leaders of environmental organizations and legislative staff.

The goal of "improved modeling, better scenarios" may have been achieved, but I am uncertain how this is measured. There has been no validation that separates calibration information from validation information, so measurement of predictive power of the model can not be a criterion for assessment, since that measurement has never been conducted. If the measurement of "improved" means that it has the acceptance of a committee, then I need to know the criterion of the committee in order to judge whether the modeling and scenarios have been improved.

The project has made progress in avoiding the type of complexity that leads to confusion, such as stating clearly how the quantity of land change is estimated in each segment, and then SLEUTH allocates the location of the pixels in order to compute the types of land covers that become disturbed. I encourage them in this direction. This is also a good way to deal with scale issues.

The project has made good decisions to focus on the drivers of change, such as population, that are coarse and have substantial momentum and have been derived by some of the stakeholders. Detailed drivers are too fickle to be useful for long term forecasts. For example, the mortgage crisis was not in the news two years ago, and will probably not be in the news after another two years, but it captures the headlines more than population projections.

Some progress has been made concerning interoperability. It seems that many challenges could be over come if it were possible to tell SLEUTH the exact number of pixels to change in each segment.

The project has given some thought and taken some action on Land Cover versus Land Use issues. But this has not been done to the extent that I recommended in 2006. I am still concerned that there might be tremendous differences in some agriculture versus other agriculture based on farmer decisions about fertilizing, water use, animal management, etc. The same can be said for lawns of private residences and institutions.

6. *Evaluate the approach used by the Bay Program to generate watershed modeling segment scale land use/land cover forecasts.*
    a. *What are the strengths and weaknesses of the approach?*
    b. *What are the limitations for using this information to inform management and policy making?*

The strength is that it is based on meaningful landscape units, such as watersheds and political units, not pixels. Another strength is that it does not take seriously the precise spatial allocation of the pixels of disturbance within the segment as specified by SLEUTH. However given this, I still do not see a tremendous value-added by predicting the pixel scale land changes. If this fine resolution is necessary to gain credibility with the public, then one must wonder how long this credibility will last, when a resident expresses concern about a specific property and then the scientists tells her that the model is not meant to be accurate at the property scale.

A major limitation is that I do not see that the scenarios and modeling are related to any specific proposed policy initiative. It would be helpful if the scenarios were based on proposed legislation. This would certainly put the modeling results in the newspaper and get people involved.

AR0014997

7. *Evaluate the responsiveness of the Phase V watershed model to forecasted changes in land use/land cover.*
    a. *How responsive is the Phase V model to forecasted land change?*
    b. *Are the modeled responses plausible? If not, please explain.*

We did not discuss the Phase V watershed model very much on the phone. I have searched the documents that I received and have not found any description of the Phase V watershed model. I assume that it is the part of the modeling project that reads land cover information and produces estimates of water quantity and quality as a function of land cover. If this is the case, then I can say that this task is very challenging and I know of no single accepted standard for doing this. The colleagues on my 10-year project have been involved in this type of modeling and it sound extremely challenging due to lack of data and complexity of the processes. This combination leads to extreme challenges in calibration and validation. One major challenge is that usually the water quality data give concentration of pollutant, which has units of mass of loading in the numerator and volume of water in the denominator. So if the concentration varies, it is difficult to know whether it is due to a change in the numerator or denominator, or both. Most of a pollutant moves during storms, when both numerator and denominator spike. It is important to consider this also when we model the impact of septic systems. Septic systems release a mass of nutrients however they also keep water local. Whereas sewers carry a volume of water potentially far away, maybe even out of the watershed. The modelers on my project have had tremendous challenges in explaining nutrient processing as nutrients move through space and time, so if the Bay program is having these same challenges, then you have plenty of company.

8. *Evaluate how the Bay Program land use/land cover products can be used with current and forthcoming land use/land cover products and potentially complementary land use/ land cover change model output (e.g., Reality Check, and SERGoM-based scenarios).*
    What are the opportunities or limitations of each product for improving adaptive water quality management responses to forecasted changes in land use/cover?

I have searched all the documents that I have and have found no mention of "Reality Check" or "SERGoM", so I cannot address those particular products. However, concerning new products, there is now tremendous potential to use Google Earth products for both analysis and public participation. Recently, my doctoral student taught me how to use Google Earth to obtain virtual ground information. You can now overlay your scenarios of future land changes on top of a current aerial photo, which would be extremely effective for town meetings, etc.

AR0014998

Reviewer #4

Overall, I am very impressed and pleased with the progress of the CBLCM. I believe that the work is well executed, thoughtful, thorough and responsive to both the STAC 2006 comments and the comments that have been made by various stakeholders. Although it is difficult to model land use change in general because of the unpredictable nature of the drivers, the team has done an excellent job at interfacing a standard land change model (i.e., SLEUTH) with various routines from other models (GAMe) and ancillary data to ensure that the model is relevant to the overall goals of the project.

I have several comments on the document entitled "CBP Response to 2006 STAC recommendations" and then identify several likely challenges that lie ahead in the final phases of the project. The CBP Response to the 2006 STAC recommendations were:

1. Less modeling, more stakeholder participation. It appears that the modeling team is interacting with the stakeholders. One of the major modifications of this interaction has been the focus on watersheds over MCDs. This seems reasonable. The team has also made various presentations to different stakeholder groups. It has also formed an Ad Hoc Technical Steering Committee.

I would like to suggest that someone on the modeling team read the report entitled "The Use of Models in Great Lakes Decision Making: An Interdisciplinary Synthesis" (www.esf.edu/es/documents/**GreatLakes**Rpt.pdf). It contains many great "lessons learned" on communicating the use of model outcomes to decision makers and other stakeholders. I have always found that miscommunication between modelers/scientists and stakeholders/general public comes from the lack of adequate focus by the modelers on articulating relevant assumptions; sometimes we are not frank about limitations of our models. In some cases, a short "what is a model and how are they to be understood" is always helpful in communicating what can and cannot be taken away from any modeling exercise. Above all, I think it is important to communicate that models should not be judged against the backdrop of "reality" but rather presented as a tool that can help simplify the complex world.

I have also had some more recent experiences of applying our land use change/hydrologic modeling (June 11-13, 2008) to watershed management. The modeling team discovered that stakeholders could use simple metrics (e.g., the percentage of an area that should remain forest) that can be applied to planning and natural resource management. Perhaps the CBLCM team might find it useful to derive simple planning metrics that could hold across the basin or be applied to critical areas of the bay area.

2. Improved Modeling, Better Scenarios. The team has delayed this portion (focus on scenarios) for now but I see this as really critical to the success of the project. A few key scenarios that engage stakeholders will help them to see clearly how different decisions alter the health of the basin.

One of my major points in 2006 was that emphasizing scenarios over prediction is more of a modeling communication paradigm. Using the term "prediction" emphasizes that you are trying your best to consider all factors of change to generate a "prediction" map in the future. Accuracy is the main aim of prediction. Scenarios, however, emphasize "plausible" futures. If modelers and stakeholders can agree that a future map is plausible, then the discussion focuses on the implications of that future map to valued outcomes. Steve Carpenter has published several papers (in the journals *Ecology, Ecosystems,*

and *Ecology & Society*) on scenario modeling that can be consulted for more detail. Many modelers are aware of this distinction but it sometimes gets lost in the conversation.

3. Complexity. This recommendation is addressed appropriately in terms of the technical (how the model is being adjusted) and philosophically. Tradeoffs between simple (easy to understand) and complex (more sophisticated routines and more complex assumptions) model structure seems to one of the classic modeling paradoxes. I prefer relying on simple models (I think that this was a consensus among our group). My feeling is that the modeling team has completed a lot of offline analysis (e.g., examining census data, remote sensing scenes, etc.) that they could provide expert opinions as to the value of incorporating more detail in the model (e.g., more drivers).

We have found that the use of short project "Bulletins" (see Supplemental Materials) are useful to communicate various aspects of the project to stakeholders. For a project that we are conducting in the Muskegon River Watershed, ten bulletins covering many different aspects of the project (e.g., damn removal, land use change analysis, land use modeling, hydrologic modeling) have been successfully used to package our results to various stakeholders. We plan another set that will be more technical that can be used by more sophisticated users (e.g., staff at state DNRs) that describe the details of the model, model validation results, etc. We will have a website that posts these pdfs as well as spreadsheets of data, GIS layers, etc. to be accessed by watershed stakeholders.

4. Scale. This seems appropriate. Alternatively, the team could consider VSEC (valley segment ecological classification) units but the hydrologic units will probably work just fine.

5. Drivers of Change. I find that adding more drivers does not appreciably add to the accuracy/goodness of the model so I really don't think that the team should devote a lot of attention to this given the other demands of the project.

6. Uncertainty. This response is reasonable and I agree that the greatest amount of uncertainty probably arises from population projections. If these are projections accepted by most stakeholders, I think the project is on solid ground here. I also think that there might be useful conversations around "what is the impact of doubling urban (or increasing urban by say 50%) do to water quality of streams" which could occur with any combination of population increase, build-out per capita ratios, etc.

7. Interoperability. This seems reasonable.

8. Land use/cover. I've always had to struggle with what the best cross walk tables might be given the use of the land change model. My only concern might be the grass land cover class ("holding it constant"). It is not clear to me if that current grassland locations are constant or the amount of grassland is held constant. I find that this is the most dynamic land use/cover class occurring in the Midwest. Modeling it is difficult; it is involved is so many different land use pathways. In some cases, grassland is a transitional class that is held by developers "ahead of the development curve"; these are speculation lands. They could also represent land that is held/enrolled in some conservation reserve program that may resort back to agriculture if crop prices climb. Overall, the grassland class can have important impacts on hydrologic dynamics and nutrient loadings.

I see several challenges that lie ahead:

1. Voluminous data. Based on the data/maps/pdfs that I downloaded and waded through, and based on our own projects that generate massive amounts of data from our models and field surveys, I think one of the greatest challenges will be to find ways to condense this information so that relevant outcomes are communicated properly. Is there a web site that houses the data, pdfs, spreadsheets, etc. that can be accessed by stakeholders? Is a web-based, GIS-enabled decision support tool eventually going to be needed? Are the Bulletins that I mentioned above possible forms to package information from various aspects of the project? I assume that some of these conversations have been started. I'd be interested in learning of any novel solutions to this challenge.

2. Scenarios. We have found these to be very useful so I hope you are able to address these with some sort of rigor. We started our Muskegon project by asking stakeholders to provide the research team with several kinds of scenarios that we knew our models could address readily. These included different build-out rates, different forest regeneration rates (have forests regrow, and compare against no new forests), the impacts of different setbacks (tape measure and ecological defined setbacks), how damn removal and bank stabilization plans might alter stream dynamics (the last are addressed using standard hydraulic models which are outside my area of expertise and that were simulated by another modeler). By comparing and contrasting these different plausible futures (along with land use maps of the past), we have been able to discern how different land use projections alter nutrient loading and hydrologic dynamics.

In another project (in East Africa), we have used visioning/expert judgment techniques to elicit input from stakeholders about what the future might look like. We use this information to help either configure new scenarios or, in some cases, generate a reference map to compare our projections against experts (they delineate areas of land use change on a map).

3. Who are the stakeholders and who are the innovators? Stakeholders differ in their receptivity to scientifically based project like this one. Some stakeholders have known agendas which are difficult to confront. Others find externalities to be more important (e.g., health of local economy) which appear in conflict with project goals and still there are others that are eager to take scientific knowledge and apply it decision making, almost to a fault. This diversity of stakeholder interest is very difficult to address and I'm sure you have run into this already. Unfortunately, I don't have any easy solutions other than to work as frequently as you can with the important stakeholders that would be impacted by this project. I have always found that the "innovators" can help clue you in to the areas of greatest resistance and suggest ways that your work could have the greatest impact. I hope you have identified some of these innovators and rely on their guidance, especially in this latter phase of the project.

Reviewer #5

Question 1: Evaluate the response of the Bay Program to recommendations from the pre-review panel.

- *Less modeling, more stakeholder participation:* Stakeholder engagement has continued and increased, particularly at the state-level. However, there still seems to be a gap with engagement of state partners and local governments. Broad-based contact with local government is critical to clearly articulate what this phase of modeling *will and will not* accomplish.
- *Improved modeling, better scenarios:* Work to date has emphasized "trend" conditions. The first STAC review provided a number of cautions about the utility of trend scenarios (e.g., the difficult managing stakeholder expectations). We have not yet seen the range of scenario recommended in the first review.
- *Complexity:* The 2006 approach has been simplified somewhat; however, there is still an impression of an overly complex approach to urban modeling that is not mirrored for the other 20+ land use/land cover classes. This disparity could introduce unknown bias into the modeling results.
- *Scale:* The Program has obviously considered this issue at length. They are articulate about the issues. That said, I believe that they should be more explicit that the results are likely to be most valuable at regional or Bay-wide scales and most problematic at county and sub-county scales. I think this needs to include conveying the difficult message that this approach will not (can not) meet all the needs and expectations of local government.
- *Drivers of change:* This may be the most fundamental weakness in the current approach. Drivers of land use/land cover change for the coming decades are presumed to mirror those over the last decade or two. This is a reasonable definition of "trend"; however, it is seems to be an increasingly unlikely scenario for the future. Concerns about energy, greenhouse gas emissions, and the costs of ever-expanding infrastructure create substantial challenges to "business-as-usual" development. These factors are not directly represented in the model and their absence may limit its value in addressing integrated policy issues.
- *Uncertainty:* The program has invested substantial time and energy in understanding uncertainty. I believe that they can reasonably articulate sources of uncertainty. It is less clear that uncertainties can be quantitatively bounded for any given scenario or any given pixel.
- *Interoperability:* Unknown
- *Land use/land cover:* The distinctions between land use and land cover issues are well-addressed by the program.

Question 2: Evaluate the approach used by the Bay Program to generate watershed modeling segment scale land use/land cover forecasts.

- What are the strengths and weaknesses of the approach?
- What are the limitations for using this information to inform management and policy making?

Strengths

The current modeling approach is capable of generating a wide-range of land use/land cover scenarios for the Bay watershed. This is an impressive accomplish and the approach is consistent with state-of-the-art practice. The tools combined in the CBLCM approach have a track record of providing plausible, policy-relevant land use scenarios. The maps generated through the modeling approach are

appropriate for addressing Bay-wide management issues where they are likely to be robust to a range of assumptions.

Weaknesses

The current modeling system has a limited ability to explore the processes driving change and substantial uncertainties remain regarding land use/land cover scenarios for individual segments and their impact on watershed modeling results. This is not necessarily an issue for the "trend" scenario created do far, but it may be a substantial issue in developing alternative scenarios. For example, by design, SERGoM provides only limited representation of land use/land cover processes and, consequently, limited opportunities to under the causes of change and corresponding management opportunities.

Policy relevance

I believe that this tool is relevant to Bay-wide or tributary-scale policy issues, such as TMDL load allocation or tributary strategy development. I do not believe it is adequate for planning or decision making at county or sub-county scales. I believe that this distinction should be clearly articulated to decision makers and stakeholders.

Question 3: Evaluate the responsiveness of the Phase V watershed model to forecasted changes in land use/land cover.

- How responsive is the Phase V model to forecasted land change?
- Are the modeled responses plausible? If not, please explain.

The Bay Program did not present information sufficient to allow for the evaluation of this question. The lack of quantitative analysis of this relationship is conspicuous and potentially problematic.

One particular issue is that the Phase V modeling approach requires a relatively large number of discrete land use/land cover categories. The level of disaggregation forces the CBLCM to attempt to predict the state of an unusually large number of variables. It is a fundamental property of land use/land cover modeling that classification error increases non-linearly with the number of categories (i.e., more categories, more error and uncertainty). This relationship is not explicitly addressed in the CBLCM approach. To date, the issue is dominated by the requirement of the Phase V model which is not directly informed by the realities of creating credible scenarios for ~25 land use/land cover categories. There is the distinct possibility that it is not possible to generate high-quality scenario for all of these variables, and no criteria for evaluating "quality" has been proposed or implemented. For example, Ponitus and colleagues (2008) conducted a detailed evaluation of land use/land cover change models. They found that, *"...the amount of error is larger than the amount of correctly predicted change for 12 of 13 applications at the resolution of the raw data."* A SLEUTH-based modeling approach also provided some of lowest overall performance in the study sample.

The current solution is to "make it work" and get an answer for each category, to some degree, regardless of quality.

Question 4: Evaluate how the Bay Program land use/land cover products can be used with current and forthcoming land use/land cover products and potentially complementary land use/ land cover change model output (e.g., Reality Check, and SERGoM-based scenarios).

- What are the opportunities or limitations of each product for improving adaptive water quality management responses to forecasted changes in land use/cover?

The Bay Program will need to address the existence of multiple land use/land cover scenarios for the Bay watershed or portions of it. The CBLCM program has been actively involved in EPA's SERGoM-based work, and it should be straight-forward to consider the implications of their scenarios.

Reality Check is something different – it is an entirely different approach to generating land use futures. It will be interesting to compare the CBLCM and Reality Check approaches with respect to map products, scenarios, stakeholder "buy-in", and cost. I would encourage the Bay Program to conduct such an assessment systematically and have a quantitative understanding of the implications of these alternative approaches.

This issue will get more important when attention turns directly to supporting the needs of local government for understanding the relationship between land use, land cover, climate, and water quality regulation. The need for public participation at these finer scales may favor Reality Check-based approaches for generating alternative futures. As with the CBLCM approach, the Reality Check approach would face a similar challenge of generating the land use/land cover categories required by the Phase V model.

The Phase V watershed modeling team might be able to help this process by attempt to modify their inputs to those factors that are available through land use/land cover modeling.

Other issues

- Gompertz Curve: this does not reflect the way SLEUTH generates urban land use – i..e., there is no negative feedback to dampened growth rates over time. In fact, SLEUTH accelerates conversion rates in a "race to the finish" (slide 15, slide 27). How is this information passed to SLEUTH?
- Compare the CBLCM approach to the application of iPLACE3S to the Sacramento metropolitan region: http://calblueprint.dot.ca.gov/index_files/BP_Report_final.pdf

APPENDIX 1

Information request to the Chesapeake Bay Program

The CBP will support the STAC paneling with written information addressing the following questions (this information may be supplemented with presentations to the panel):

1. How does the Chesapeake Bay Program use information about land use/land cover patterns and processes to meet its goals of restoring water quality and living resources?
    a. What are the short and long-term goals of the land use/land cover research?
    b. What resources are available to understand land use/land cover changes in the watershed?
    c. Does the CBP recognize any comparable programs?

2. How does the land use/land cover modeling program support these goals? Specifically:
    a. Can the modeling approach provide the required set of credible information products?
    b. How are specific land use/land cover scenarios developed?
    c. How does the modeling generate projections for the full range of land use and land cover types required by the watershed model?
    d. What are the most important limitations and uncertainties associated with the proposed approach and its implementation?
    e. Is the watershed model sensitive to the range of projected changes in land use/land cover?

3. Technical modeling approach
    a. What are the goals, timeline, models, and specific products expected from proposed modeling approach?
    b. What are the most important assumptions and parameters?
    c. How will models be integrated?
    d. How will modeling products be translated into information about each of the land use and land cover elements required for hydrologic modeling? The outside reviewers will require a specific answer based on specific data products (*e.g.*, RESAC land cover).
    e. How will the approach distinguish between land use and land cover issues (what problems could this cause)?
    f. Who is the intended audience for the model output and how will they be engaged in product development, evaluation, and use?
    g. What products will be available to users?
    h. Will the models, data, and parameters be accessible to the research community? If so, on what terms?

AR0015005

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